INTERIM HYDROGEOMORPHIC FUNCTIONAL ASSESSMENT MODEL FOR GROUNDWATER DISCHARGE, LOW PERMEABILITY (GLACIAL TILL) SUBSTRATE, SLOPE (LINEAR) WETLANDS IN THE NORTHERN PLAINS

Version 4.0

By

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Section I. Introduction

General

Wetlands have properties of both aquatic and terrestrial ecosystems. Their most widely valued function is providing habitat for fish, birds, animals, and macro- and microorganisms. They contribute to the maintenance of biological diversity. In addition to this “food chain support” function, wetlands carry out hydrologic functions and biogeochemical “processing” functions, all of which are important to society as a whole. They also provide recreational, educational, research, and aesthetic functions.

Overview

There are three components to the hydrogeomorphic approach to wetland functional assessments (HGM). These are: (1) hydrogeomorphic classification system; (2) reference wetlands; and (3) assessment models/functional indices.

There are some physical attributes that are associated with the characterization of wetlands using HGM. These attributes are identified and defined, below.

Wetland Hydrology. This is the study of water, including the characteristics of surface and subsurface water flow, and its interaction with the wetland.
Geomorphology. This is the study of the earth’s surface and its formation, commonly defined by the contours of the earth’s surface.
Geomorphic Setting. This defines the landscape position that a wetland occupies. (Examples include depressions, valleys, and flood plains.) Geologic evolution (layering of geologic and soil materials which affect water flow) and topographic position in a landscape (top, middle, or bottom of a watershed and stream orders) are considered factors which contribute to geomorphic setting.

Hydrogeomorphic Classification

Hydrogeomorphic classification is based on three factors: geomorphic setting, water source, and hydrodynamics. Regardless of how they are defined, all wetlands share some common hydrologic, soil, and vegetative characteristics. Beyond these similarities, however, wetlands exhibit wide variation in terms of their size, complexity, and physical, chemical, and biological characteristics and processes.

At the highest level of HGM classification, wetlands are grouped into hydrogeomorphic wetland classes. Seven hydrogeomorphic classes are recognized. They include depressions, lacustrine fringes, tidal fringes, slopes, riverine systems, mineral soil flats, and organic soil flats.

Wetland Functions

Wetland functions are the normal or characteristic ecological processes that take place in wetland ecosystems. Wetlands perform a wide variety of functions that are governed by their physical, chemical, and biological attributes. Not all wetlands perform the same functions. A specific class of wetland will perform similar functions, but it is usually at the subclass or more defined level at which a group of wetlands perform the same functions. Even at this level, similar wetlands do not always perform functions to the same degree or magnitude. The functions selected for assessment should reflect the characteristics of the wetland ecosystem and landscape under consideration and the assessment objectives. By narrowing the focus to a regional subclass, it is possible to identify the functions that are most likely to be performed and of greatest benefit to the public interest.

The hydrogeomorphic system of wetland classification recognizes three broad categories of functions wetlands perform. They include functions related to hydrology, biogeochemical processing, and wildlife/biological habitat. Specific wetland functions have been identified within the three broad categories. Moderation of groundwater flow is an example of a slope wetland function. It can be defined as "the capacity of the wetland to regulate the outflow of groundwater. Effects on-site include contribution to the maintenance of characteristic soils, vegetation, invertebrate and vertebrate communities, and the moderation of groundwater flow. Effects off-site include modification of off-site hydrology of wetland and riverine systems within the groundwater and surface water flow network.

Reference Standards

In order to assess impacts to wetland functions, standards of comparison must be defined for what constitutes chemical, physical, and biological integrity in the context of a wetland. Establishing reference standards has two complications.

First, wetland ecosystems and their surrounding landscapes are dynamic and constantly changing. As the characteristics that influence function change, functional capacity may increase or decrease. These changes are the result of natural short-term processes such as seasonal cycles of precipitation and temperature; and long-term processes that include population dynamics, erosion and depositional processes, succession, drought/wet cycles, or sea level rise. In establishing reference standards, the variability that occurs as a result of natural processes must be taken into account.

Second, establishment of reference standards is further complicated by the variability exhibited by wetland ecosystems and landscapes in response to anthropogenic disturbance. Land-use changes and hydrologic alteration of wetland ecosystems and their surrounding landscapes and the resultant lack of undisturbed wetland ecosystems and landscapes makes it difficult to establish reference standards that reflect the functional capacity of a regional subclass under undisturbed conditions.

Reference Wetlands and Reference Domain

Because wetland ecosystems exhibit a wide range of conditions as a result of natural processes and anthropogenic disturbances, and few undisturbed wetland ecosystems or landscapes exist, this assessment approach establishes reference standards based on reference wetlands. Reference wetlands are actual wetland sites that represent the range of variability exhibited by a regional wetland subclass as a result of natural processes and anthropogenic disturbances.

In establishing reference standards, the geographic area from which reference wetlands are selected is the reference domain. The reference domain may include all, or part, of the geographic area in which the regional subclass actually occurs.

Once the reference domain has been defined, there are a variety of approaches for selecting reference sites, establishing the variability of a regional subclass in a reference domain, and defining reference standards.

Functional Indices and Assessment Models

Assessment models are simple representations of the relationship between attributes of the wetland ecosystem and the surrounding landscape, and the functional capacity of the wetland. Variables in the assessment model, such as plant species composition, over bank flow, and soil type, represent the attributes. Variables are assigned a sub-index ranging from 0.0 to 1.0 based on the relationship between the variable and functional capacity.

Variables in the assessment model are assigned a sub-index based on a quantitative (i.e., interval or ratio) or qualitative (i.e., nominal or ordinal) scale data. When it is impossible or impractical to assign a sub-index based on direct, quantitative or qualitative data, it may be possible to assign a sub-index based on an indicator. Indicators are easily observed or measured characteristics that are correlated with a quantitative measure of a variable.

In addition to defining the relationship between variables and functional capacity, the assessment model defines how variables interact to influence functional capacity. The interaction between variables is defined using an aggregation function or logical rules. The result is a functional capacity index (FCI), which is the ratio of the functional capacity of a wetland under existing conditions, and the functional capacity of a wetland exhibiting reference standards for the regional subclass in the reference domain.

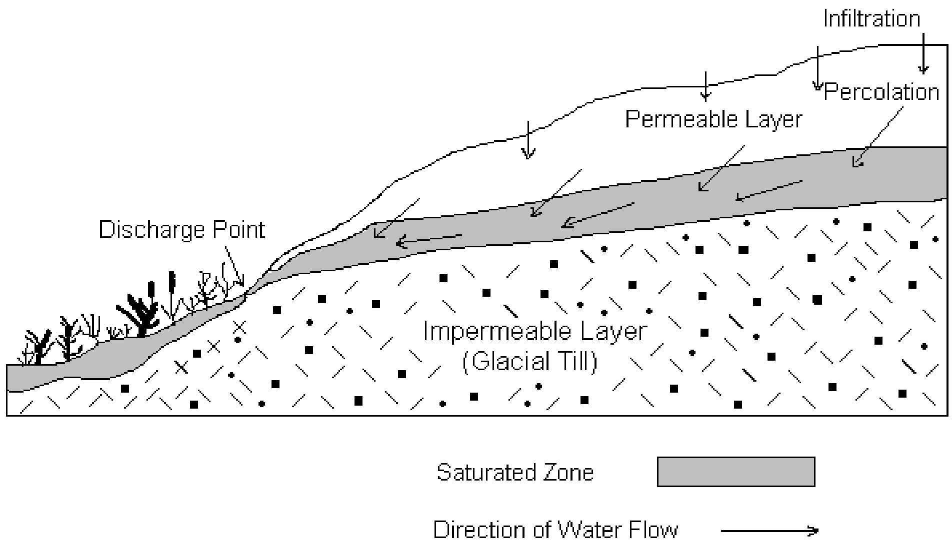
Functional Profile of Slope Wetlands

Slope wetlands normally are found where there is a discharge of groundwater to the land surface. They normally occur on sloping land; elevation gradients may range from steep hillsides to nearly level footslopes. These wetlands commonly occur at “nick points” on the landscape, or areas where the land surface changes or where stratigraphic (geologic) discontinuities occur. Slope wetlands are generally incapable of depressional storage because they lack the necessary closed contours, although they may contain small basins which hold water for very brief periods (less than 7 days) during precipitation events. These wetlands often provide some connectivity between depressional wetlands. Principal water sources are groundwater return flow and inter-flow from surrounding uplands, as well as precipitation. They have characteristic hydrology, soils, and vegetation that differ from adjacent upland landforms.

This model has applicability for use in assessing linear wetlands on low gradient slopes and with slowly or very slowly permeable substrates. The reference domain, or area of initial application, for this model is eastern South Dakota (east of the Missouri River), eastern North Dakota, western Minnesota, and northeastern Nebraska. Slope wetlands within this domain have variable gradients; generally they are less than 2 percent, but may be as high as 6 to 8 percent at the upper end of some watershed areas and along breaks associated with larger streams. They are discharge wetlands, having at some depth glacial till that has slow or very slow permeability, thereby restricting downward movement of water. Climate for the area ranges from semi-arid to subhumid. The slope wetland class has been defined by Brinson, et. al. (1993). After testing and revising the model, the reference domain for its application may be expanded.

Figure 1. Geomorphology of a Slope Wetland

Cross-sectional View



The following summary describes the hydrologic, soil, and vegetative features that should be considered characteristic for the assessment of this subclass of wetlands.

<u>Hydrology</u>

Hydrodynamics of slope wetlands are dominated by down slope unidirectional water flow. Groundwater discharge is the principle source of water to these wetlands during most of the year. Surface water (overland flow) normally occurs in slope wetlands during periods of snowmelt and immediately following rainfall events. Overland flow typically occurs for brief or very brief periods (7 days or less), but may occur for longer periods when soils are saturated or during extended periods of above-normal precipitation. Slope wetlands can occur on nearly level landscapes if groundwater discharge is a dominant source of water to that wetland. Slope wetlands lose water primarily by evaporation of surface water and by transpiration. Slope wetlands may develop channels, but the channels serve only to convey water away from the wetland. Slope wetlands may receive water from wetland ecosystems upstream. They commonly supply water to downstream wetland ecosystems.

<u>Soils</u>

Soils within the reference domain are generally characterized as loess over glacial till. The till provides a restrictive layer to downward movement of water, causing water to move laterally along the interface of the loess and till. The thickness of the loess varies but is commonly 2 to 4 feet. Where the loess layer is thin, water movement along this interface may occur at or near the surface, creating a slope wetland. Soils associated with slope wetlands may exhibit weak development or they may be well developed. Their morphology varies depending on landscape position, slope, and local geomorphology. They are medium to fine textured soils and are typically high in organic matter.

Vegetation

The vegetative community in slope wetlands is dominantly herbaceous. The herbaceous plant community is similar in composition and abundance to communities found on other classes of wetlands in the Prairie Pothole region. In some situations (such as where the wetlands have been historically manipulated, or where slope wetlands grade into riverine ecosystems), woody species such as willows (Salix spp.) may occur as a minor component. These may be considered invader species in situations where past manipulations (such as severe overgrazing) has caused a shift in the overall plant community. Woody species may occur naturally in areas where slope wetlands grade into riverine ecosystems.

Fish and Wildlife Service National Wetland Inventory (NWI) classification of this subclass is typically PEMA, PEMB, and PEMC; they may occasionally be identified as PFOA, PFOC, PSSA, or PSSC.

Section II. Discussion of Slope Wetland Functions and Associated Functional Indices

1.0 MODERATION OF GROUNDWATER FLOW

DEFINITION: The capacity of the wetland to regulate the outflow of groundwater.

Effects On Site: Contributes to the maintenance of characteristic soils, vegetation, invertebrate and vertebrate communities, and provides for the moderation of groundwater flow.

Effects Off-Site: Modifies off-site hydrology of wetland and riverine systems within the groundwater and surface water flow net.

Discussion of Function

A combination of geological material and regional water balance affects groundwater and surface water flow within the wetlands. The principal water sources for slope wetlands are from groundwater and precipitation and the principal water losses are through evaporation and transpiration. Surface runoff contributes to water loss during wet periods such as snowmelt and excess precipitation events. These hydrological elements produce an inter- and intra-annual cycle of water storage within the wetland boundaries. This cycle supports diverse plant and animal habitats as well as biogeochemical processes. These sloped wetlands sustain the hydrological cycle. The hydrological dynamics of the Prairie Pothole Region are addressed by Stewart and Kantrud (1972), Winter (1989) and Kantrud et al. (1989).

Discussion of Variables

The variables associated with the performance of this function focus on land use and on the physical integrity of soil conditions. Human activities at nearby lower elevations and above or within the wetland affect the rate and quantity of surface and subsurface water entering and leaving the wetland. $\mathbf{V_{upuse}}$ and $\mathbf{V_{source}}$ are used to describe potential alterations of water flow to the wetland. The abundance and type of permanent vegetation present within the wetland ($\mathbf{V_{pcover}}$) affects water flow through the wetland. Land use activities also affect erosion and sediment import into the wetlands by water and wind. Soil conditions within the wetland affect the ability of the soil to transmit and hold water interstitially. This soil condition is described in the $\mathbf{V_{pore}}$ variable. Finally, constructed drainage features in and adjacent to the wetland directly impacts the subsurface flow of water to and from the wetland. The $\mathbf{V_{subalt}}$ variable reflects this aspect of the function.

Index of Function:

$$=\{V_{subalt} \times [(V_{source} + V_{upuse})/2 + (V_{pore} + V_{pcover})/2]\ /2\}^{1/2}$$

2.0 VELOCITY REDUCTION OF SURFACE WATER FLOW

DEFINITION: The reduction in the velocity of surface water movement through the wetland from storm events and/or snowmelt runoff.

Effects On-Site: Maintains characteristic soils, vegetation, invertebrate and vertebrate communities, provides for erosion reduction in the wetland, and aids in the nutrient and chemical cycling process.

Effects Off-Site: Erosion reduction and retention of elements and compounds on site decreases probability of export to aquatic ecosystems downstream.

Discussion of Functions

Vegetation and microtopographic changes within the wetland provide a structural roughness to reduce the velocity of overland flow in and out of the wetland. Reduction of flow velocity through the wetland allows time for the settlement of water-born sediments and nutrients within the wetland. The density of vegetation present within the wetland also provides for erosion control.

Discussion of Variables

The variables used to extrapolate an index of function reflect the physical condition of the wetland and its contributing watershed area. Physical attributes of the wetland are reflected in the topographic relief of the wetland surface ($\mathbf{V_{micro}}$); vegetation density ($\mathbf{V_{pcover}}$); surface hydrologic alterations present ($\mathbf{V_{surfalt}}$); and, presence of excessive sedimentation ($\mathbf{V_{sed}}$). External attributes which influence the movement of surface water to the wetland include use and condition of the upland watershed area ($\mathbf{V_{upuse}}$), presence of physical manipulations to the contributing watershed area ($\mathbf{V_{source}}$), and presence and condition of the buffer adjacent to the wetland ($\mathbf{V_{buffer}}$).

Index of Function:

$$= [V_{micro} + V_{pcover} + V_{surfalt} + (V_{buffer} + V_{sed} + V_{source} + V_{upuse})/4] /4$$

3.0 ELEMENTAL AND NUTRIENT CYCLING

DEFINITION: Short- and long-term cycling and removal of elements and compounds on-site through the abiotic and biotic processes that convert elements from one form to another.

Effects On-Site: Net effects of retention, conversion, and release are balanced between gains through import processes and losses through hydrologic export, efflux to the atmosphere, and long term retention in persistent biomass and sediments.

Effects Off-Site: Retention of elements and compounds on-site decreases probability of export to other aquatic ecosystems downstream and consequently to nutrient loading of downstream aquatic ecosystems.

Discussion of Functions

The use of the term cycling refers to the annual turnover of nutrients and retention refers to the relatively long-term accumulation or loss through conversion or removal of elements and compounds from incoming water sources. Elements include macronutrients essential to plant growth (nitrogen, phosphorous, potassium) and other elements such as heavy metals (zinc, chromium, etc.) that can be toxic at high concentrations. Mechanisms of nutrient cycling, retention, conversion, release and removal include sorption, sedimentation, denitrification, burial, decomposition to inactive forms, decay, uptake and incorporation into short- and long- lived annual and perennial herbaceous biomass, and similar processes [Brinson et al. (1985)].

Discussion of Variables

The variables within this function reflect land use, abiotic, and biotic components. Land use activities impact the magnitude of elements and compounds entering the system and the natural cycling and removal processes of the elements and compounds. Inputs into the system can be captured within the upland use ($\mathbf{V_{upuse}}$) variable.

Biotic components of the wetland ecosystem cycle and retain elements and compounds through biomass accumulation in living matter and litter. Elements and compounds are recycled annually through decay and decomposition. Neely and Baker (1989) report decay rates for some emergent plants in the Prairie Pothole region to be greater than one year, indicating retention. These decomposition rates facilitate both cycling on an annual basis and retention on a longer than one year basis within the wetland. Biotic components consist of the soil organic matter and detritus variables ($\mathbf{V_{som}}$ and $\mathbf{V_{detritus}}$, respectively).

The abiotic components assist reduction and oxidation processes that biogeochemically cycle and retain elements and compounds. Abiotic components are represented by soil quality ($\mathbf{V_{pore}}$), and by the amount and presence of water (represented by the $\mathbf{V_{surfalt}}$ and $\mathbf{V_{source}}$ variables).

Index of Function:

$$= \{[(V_{som} + V_{detritus})/2] \times [V_{pore} + (V_{surfalt} + V_{source} + V_{upuse})/3] /3\}^{1/2}$$

4.0 RETENTION OF PARTICULATES AND ORGANIC MATERIAL

DEFINITION: Deposition and retention of inorganic and organic particulates (>45 um) from the water column, primarily through physical processes.

Effects On-Site: Organic matter may be retained for decomposition, nutrient recycling, and detrital food web support. Sediment accumulation contributes to the nutrient capital of the ecosystem. Deposition increases surface elevation and changes topographic complexity. Natural rates of accumulation are slow.

Effects Off-Site: Reduces potential export of sediment and other particulates to downstream wetland and aquatic ecosystems and groundwater systems.

Discussion of Function

Retention applies to particulates arising from both on-site and off-site sources, but excludes in situ production of peat. The Retention of Particulates function contrasts with the Retention, Conversion, and Release of Elements and Compounds function in that the emphasis is more dependent on physical processes such as sedimentation and particulate removal. Sediment retention occurs through burial and chemical precipitation (i.e. removal of phosphorous by Fe^{+++}). Dissolved forms may be transported as particles after undergoing sorption and chelation (heavy metals mobilized with humic and fulvic compounds). Imported sediment can undergo renewed pedogenesis on-site, which potentially involves weathering and release of elements that were previously inaccessible to mineral cycling (Brinson, 1995).

Discussion of Variables

The variables associated with the performance of this function focus primarily on components of the system that affect the physical processes of particulate removal and sedimentation. Because of the position on the landscape occupied by these wetlands, a primary source of sediment would be from uplands as particulates transported in overland flow. Therefore, use of the uplands ($\mathbf{V_{upuse}}$) has a direct influence on the potential delivery of sediment to these ecosystems. The presence (or absence), continuity, and condition of the buffer zone ($\mathbf{V_{buffer}}$) around the margin of the wetland affects surface flow into the wetland from adjacent uplands. The density of vegetation present within the wetland, and associated usage (represented by $\mathbf{V_{pcover}}$) will affect the ability of the wetland ecosystem to perform this function, and will have an influence on the variability of related functional indices. The variable ($\mathbf{V_{sed}}$) represents evidence of accelerated sedimentation within the wetland.

Index of Function:

$$= [\, V_{sed} + (V_{buffer} + V_{pcover} + V_{upuse})/3] \,/2$$

5.0 ORGANIC CARBON EXPORT

DEFINITION: Export of dissolved and particulate organic carbon and detritus from the wetland. Mechanisms include processes such as leaching, flushing, displacement, and erosion.

Effects On-Site: The removal of organic matter from living biomass, detritus, and soil organic matter contributes to carbon turnover (plant storage) and food web support.

Effects Off-Site: Provides support for food webs and biogeochemical processing from the wetland ecosystem.

Discussion of Function

Wetlands export organic carbon at higher rates per unit area than terrestrial ecosystems (Mulholland and Kuenzler, 1979) in part because surface water has greater contact time with organic matter in litter and surface soil. While the molecular structure of most organic material is not well known because of its chemical complexity (Stumm and Morgan, 1981), organic matter nevertheless plays important roles in geochemical and food web dynamics. For example, organic carbon complexes with a number of relatively immobile metallic ions that facilitate transport in soil (Schiff et al., 1990). Organic carbon is a primary source of energy for microbial food webs (Dahm, 1981; Edwards, 1987; Edwards and Meyer, 1986) which form the base of the detrital food web in aquatic ecosystems. These factors, in combination with the proximity of wetlands to aquatic ecosystems, make wetlands critical sites for supplying both dissolved and particulate organic carbon.

Discussion of Variables

Two factors are required for slope wetlands to export organic carbon. These factors are a source of organic material and water flow for transport. The density of the plant community within and surrounding the wetland influences the input of organic material ($\mathbf{V_{pcover}}$) into the wetland. This input is in the form of both the living and dead vegetation ($\mathbf{V_{detritus}}$). Sequestration of organic carbon in wetland soils, as indicated by ($\mathbf{V_{som}}$), aids in the turnover of carbon within the wetland and in the export of organic material downstream. Water movement into and through the wetland can be characterized by wetland surficial complexity ($\mathbf{V_{micro}}$) and by restrictions in or alterations to subsurface and surface hydrology ($\mathbf{V_{subalt}}$ and $\mathbf{V_{surfalt}}$, respectively). When precipitation rates exceed soil infiltration rates, overland flow in uplands adjacent to slope wetlands can transport both dissolved and particulate organic carbon into and through a wetland. Subsurface inflow contributes to organic carbon export. Displacement of existing soil water within alluvium may create outflow through surface and subsurface pathways to downstream localities.

Index of Function:

$$= [V_{detritus} + V_{pcover} + V_{som} + (V_{micro} + V_{subalt} + V_{surfalt})/3] /4$$

6.0 MAINTENANCE OF CHARACTERISTIC PLANT COMMUNITY

DEFINITION: The species composition and physical characteristics of living plant biomass. This function not only reflects the plant community, but also is assumed to be an indicator of the presence or potential presence of vertebrates and invertebrates. Historic climax plant communities are not dominated by exotic or nuisance species. Vegetation is maintained by mechanisms such as seed dispersal, seed banks, and vegetative propagation, which respond to variations in hydrology, and disturbances such as fire and herbivores. The emphasis is on the temporal dynamics and structure of the plant community as revealed by vegetative species composition, abundance, and percent cover.

Effects On-Site: Creates microclimatic conditions that support plants and animals. Converts solar radiation and carbon dioxide into complex organic carbon that provides energy to drive food webs. Provides habitat for feeding, nesting, resting, escape, and breeding for resident and migratory vertebrates and invertebrates.

Effects Off-Site: Provides a source of vegetative propagules for adjacent ecosystems, which assists in revegetation following drought or disturbance and provides for gene flow between populations. Provides habitat for vertebrates and invertebrates from adjacent ecosystems.

Discussion of Functions

Vegetation accounts for most of the biomass of slope wetland systems. The physical characteristics of living and dead plants are closely related to ecosystem functions associated with hydrology, nutrient cycling, and the abundance and diversity of animal species (Lillie and Evard, 1994). Vegetation is not static, however, and species composition and physical characteristics change in space and time in response to natural and anthropogenic influences (Weller, 1987).

Discussion of Variables

The variables within this functional index address plant community characteristics and potential anthropogenic disturbance.

Plant community characteristics change with various types of man-induced disturbances. The ratio of native to non-native plant species ($\mathbf{V_{pratio}}$) indicates the health of a plant community. A healthy, diverse plant community is comprised of a high percentage of native noninvasive plants. As a system becomes perturbed, invasive native and non-native species out-compete sensitive native species. Plant abundance, as measured by percent cover ($\mathbf{V_{pcover}}$), captures the ability of the system to remain self-sustaining. Detritus ($\mathbf{V_{detritus}}$) maintains thermal regulation of rhizospheres and propagules, and is essential for nutrient cycling.

The elements of a healthy, diverse plant community may be compromised by anthropogenic activities. Hydrophytic plants are directly affected by water level and soil moisture regime. The altering of wetland hydrology impacts groundwater and surface water levels within the wetland, and is reflected in the variables $\mathbf{V_{subalt}}$ and $\mathbf{V_{surfalt}}$.

Index of Function:

$$= [V_{pcover} + V_{pratio} + (V_{detritus} + V_{subalt} + V_{surfalt}) /3] /3$$

7.0 MAINTENANCE OF HABITAT INTERSPERSION AND CONNECTIVITY AMONG WETLANDS

DEFINITION: The spatial relationship of an individual wetland with respect to adjacent wetlands in the complex.

Effects On-Site: The assessed wetland contributes to habitat features of the wetland complex by virtue of its position in the landscape.

Effects Off-Site: Contributes to overall landscape diversity of habitat for aquatic and terrestrial organisms.

Discussion of Functions

Wetlands provide water and other life requirements for motile species. In addition, all vegetative strata in wetlands, from herbaceous layer to tree canopy, provide wildlife corridors (connections) between different wetland types, between uplands and wetlands, and between uplands (Sedell et al., 1990).

Discussion of Variables

Uninterrupted corridors are critical for movement of animals within and between wetlands. The integrity of these corridors may be disturbed through human-induced disturbances both within and around the assessment area. The extent of these disturbances is represented by the variables $\mathbf{V_{upuse}}$, $\mathbf{V_{pcover}}$, and $\mathbf{V_{buffer}}$. $\mathbf{V_{upuse}}$ represents the use of the upland watershed area. $\mathbf{V_{pcover}}$ is a surrogate indicator of the use of the wetland, as evidenced by the presence or absence, and density, of permanent vegetation. Maintenance of water levels within the wetland is important to maintenance of habitat functions. Alterations that impact water levels are reflected in the $\mathbf{V_{subalt}}$ and $\mathbf{V_{surfalt}}$ variables. $\mathbf{V_{buffer}}$ represents the vegetative buffer along the wetland, including buffer condition, continuity, and width.

The pattern of different types of wetlands and the frequency of distribution of wetland sizes within a radius of one mile relates to the animal guilds that use the wetlands. Wetlands are dynamic, integrated systems that provide habitat for numerous wildlife species.

Index of Function:

$$= [V_{buffer} + V_{pcover} + V_{upuse} + (V_{subalt} + V_{surfalt}) /2] /4$$

Section III. Field Guide for the Measurement of Indicators: A Procedure for the Assessment of Slope Wetlands

Introduction

This section serves as an aid in the hydrogeomorphic assessment of functions pertaining to dominantly ground water discharge, slope wetlands in the Prairie Pothole region of eastern South Dakota. Information recorded will be used as the basis for determining gains and losses in wetland functional capacity.

Prior to proceeding with the office review of the functional assessment, an initial review of the project or site proposal needs to be done to fully understand the reason for doing the functional assessment and the scope of assessment needed.

Recommended Steps in the Functional Assessment of Slope Wetlands

A. Office Preparation

1. Review the "Recommended Tools" list (page 19) and assure needed tools are available to do the assessment.

2. Prior to performing the office review, it is important to collect documents and any other information that is relevant to the site. Pay particular attention to the land use of the assessment site, noting any differences in land use within or surrounding the wetland.

3. Gather and record any pertinent information on the history of the wetland, including its past and present use, as well as the past and present use of the contributing watershed area. Local technical specialists should be consulted regarding this type of information. Past manipulations to watershed or wetland hydrology, as identified by the variables V_{source}, V_{subalt}, and $V_{surfalt}$ can often be identified in the field office. Prepare the tools needed for the field assessment.

4. Take recorded comments and data to the field with you.

B. Field Assessment

The interim functional assessment model for slope wetlands contains 15 indicators, or variables, which are used in various combinations (equations) in order to assess functional capacity of the wetlands. A series of steps is recommended for use in the rating of these indicators. The indicators themselves are independent of each other, although similar measurements and/or conditions are used to rate several of them. These indicators have been identified as being important to the overall function of slope wetlands.

Before evaluating each of the indicators, a general evaluation of the wetland assessment area should be made. The evaluator(s) should first separate the wetland area from the upland, and determine that the area to be assessed is a slope wetland. Most slope wetlands are easily identifiable. Some wetlands associated with riparian (riverine) ecosystems may require more extensive evaluation. US Fish and Wildlife Service NWI maps should aid in making difficult classification determinations.

The wetland area should be visually examined by walking through and around it. Check location and condition of assessment indicators such as buffer area, source area, adjacent uplands, and the wetland area. A representative assessment area within the wetland needs to be identified. In most circumstances one assessment will be sufficient. Some circumstances, such as with long, linear slope wetlands, may require evaluation of two or more assessment areas.

After the assessment area has been identified, follow the detailed instructions on the measurement of indicators. Variable index scores can be recorded in the worksheet (Form 1); functional capacity indices (FCI's) can be calculated from the worksheets contained in Form 2; functional capacity units (FCU's) can be calculated using the worksheets contained in Form 3. (A Microsoft Excel® spreadsheet has been developed for use in calculating FCI's and FCU's.) Before leaving the site, check to insure that you have all the needed field data collected and recorded. Review the data to see if it makes sense and recheck data that appears questionable.

Assessment Indicators (Variables)

Detritus ($V_{detritus}$). Detritus consists of a mat of litter in various stages of decomposition that is prostrate and in contact with the soil surface. The thickness of detritus within the wetland assessment area is measured or estimated. Variability in the thickness of the detrital layer will dictate the number of measurements needed in order to obtain an average.

Sedimentation in the Wetland (V_{sed}). This provides a measure of sediment accumulation within the wetland. Only sediment of contemporary origin, most commonly from agricultural sources, should be considered. An actual measurement can be obtained, or visual observations of recent deposition on the wetland surface made and recorded.

Soil Pores (V_{pore}). This provides an evaluation of the physical integrity of the soil. Primary attention is to the surface layer and upper part of the subsoil, or from 0 to about 20 inches depth. Visual observations are made regarding abundance and size of soil pores, as well as texture, soil structure, and rupture resistance.

Soil Organic Matter (V_{som}). This provides an indication of the ability of the wetland soil to retain and release elements and compounds. Visual observations of the soil are made regarding texture, color, and overall organic matter levels.

Buffer Condition, Continuity, and Width (V_{buffer}). This variable provides for an assessment of the land adjacent to the wetland. The land within 100 feet of the outermost edge of the wetland should be evaluated. Land use and condition, and continuity and average width of that area that is in permanent vegetation, are considered in the rating process. Visual observation, average measurements, and best professional judgment are used to evaluate this variable.

Vegetation Density (V_{pcover}). This provides an evaluation of the abundance of woody and herbaceous plants in all vegetative zones within the wetland. Visual observation and estimates of vegetative ground cover are used to evaluate vegetation density.

Ratio of Native to Non-Native Species (V_{pratio}). This measures the ratio of native to non-native plant species present in the wetland as indicated by the top 4 dominants, or by a more extensive species survey. Visual observation and estimates of vegetation ratios are used to determine this index.

Microtopographic Complexity (V_{micro}). This provides an assessment of the surficial roughness of the wetland. Direct measurements using surveying equipment can be taken and used to illustrate the wetland surface. These measurements, in combination with visual observations of the assessment area and best professional judgment, are used to rate the condition of the area.

Source Area of Flow Intercepted by Wetland (V_{source}). This assesses the watershed contributing to the wetland and the effect various cultural disturbances have on the wetland water cycle. An examination of USGS quadrangles and aerial photography of the area, as well as an on-site visual assessment, would provide an estimate of potential impacts any disturbances may have to the wetland source area.

Subsurface Hydrology Alterations (V_{subalt}). This identifies any constructed subsurface alteration(s) to the contributing wetland hydrology and assesses the impact the alteration(s) has. Such alterations can have a detrimental effect on wetland ground water elevations. Survey equipment can be used to establish baseline hydrologic data.

Surface Hydrology Alterations ($V_{surfalt}$). This identifies any constructed surface alteration(s) to the contributing wetland hydrology and assesses the impact the alteration(s) has. Such alterations can have a detrimental effect on wetland ground water and surface water elevations. Survey equipment can be used to establish baseline hydrologic data.

Upland Use (V_{upuse}). This identifies and evaluates the dominant land use and condition of the uplands that constitute the wetland watershed area. Visual observation of the dominant use and condition of the upland is made.

Recommended Tools to Use for Wetland Assessment

Office Tools

USGS Quadrangle Maps
USFWS NWI Maps
Aerial Photography of Wetland and Surrounding Watershed Area
Soil Survey Publication
Engineering Field Manual
Engineers Scale
Tools for Acreage Calculation
FSA Color Slides
NRCS County Wetland Inventories

Field Tools

Slope Wetland Interim Functional Assessment Model
Aerial Photography of Wetland and Surrounding Area
Surveying Equipment:
- Hand, Abney, or Transit Level
- Rod or Stadia Board
- Measuring Device (such as 100' chain)

National List of Plant Species
Plant Identification Handbooks
Plant press, plastic bags, and labeling materials
Spade, Soil Probe, or Auger
Soil Field Kit, including:
- Munsell Color Book
- Tape Measure (English and Metric)
- Steel Spatula or Knife
- Acid
- Water
- Field Indicators of Hydric Soils in the United States
- Hand Lens

Field Recording Sheets
Clipboard, Paper, Pencils
Flags (two or more colors desirable but not necessary)
Tube Markers
Calculator
Photographic Equipment (optional)
Tile Probe (optional)

Other Considerations

Insect Repellent
Sun Screen
Hip or Chest Waders, or Rubber Boots
Binoculars
Laptop Computer with M.A.R.S.H. Plant ID Program, Excel or Lotus Spreadsheet
Global Positioning System
Containers for Plant Collection
EDTA Solution
Local Representative (knowledgeable about area resources and land uses)

Detritus

Where to Measure

Detritus is to be measured within the wetland. The assessment area should be scouted, and a representative site selected for sampling. If it appears that the thickness of the detrital layer is highly variable, several sampling points should be selected, and an average thickness determined.

When to Measure

Measurement of detritus can be taken at any time during the assessment procedure. For efficient use of time, it is best to collect measurements in conjunction with the delineation procedure or in conjunction with collecting data for the V_{sed} and V_{som} variables.

What and How to Measure

Detritus is the mat of dead plant and animal material that is in contact with the soil surface. The current years growth is normally excluded from the detrital layer. Detritus occurs in various stages of decomposition. Two methods for determining detritus thickness work equally well, depending on the thickness of the detrital layer.

<u>Preferred Method</u>
The index finger can be used to measure detritus if the thickness doesn't exceed about 8 cm. Carefully insert the finger through the detritus until it comes in contact with the surface of the soil (commonly characterized by a cool, damp, slippery feeling). Care should be taken not to compact the detrital layer. The thickness can be noted on the finger, measured, and recorded. If the detrital layer exceeds about 8 cm. thickness, a ruler or tape measure can be used directly. A narrow slit should be made through the layer and a measuring device inserted until it comes to rest on the soil surface.

<u>Alternate Method</u>
A spade can be used to remove a plug of soil and the overlying detrital layer. This method disturbs the layer and commonly causes some compaction. An estimate of the amount of disturbance should be made, and the detrital layer measured and recorded.

If the sampling site is inundated with water, the use of a soil probe with a 1.5" diameter tube would be more practical than use of a spade. Compare the cored samples to the detrital mass in the wetland. Coarse or fibrous material may slide around the probe tip. If the core samples do not match the source area, another one of the previous sampling techniques should be used.

What to Record

Month or season measurement is taken ________________

Representative or Average Thickness of Detritus in the Wetland ____________cm.

$V_{detritus}$: Detritus

Model Variable	Measurement or Condition	Index
DEFINITION: The thickness of the matted layer of litter derived from previous years' vegetative growth in the wetland. Detritus normally occurs in various stages of decomposition. **NOTE:** Only plant debris that is prostrate and in direct contact with the soil surface should be considered. Soil "O" horizons are considered organic material and should be included in the detritus layer. The entire wetland assessment area should be considered. If the detritus layer within the assessment area is highly variable, use an average thickness for rating.	Litter layer thickness in: Winter/spring (Dec.-May) is 6 to 10 cm. (2.25 to 4 in.) Summer (June-Aug.) is 4 to 7 cm. (1.5 to 2.75 in.) Fall (Sept.-Nov.) is 2-5 cm. (0.75 to 2 in.)	1.0
	Litter layer thickness in: Winter/spring (Dec.-May) is 3 to <6 cm. or >10 cm. (1.25 to <2.25 in. or >4 in.) Summer (June-Aug.) is 2.5 to <4 cm. or >7 cm. (1 to <1.5 in. or >2.75 in.) Fall (Sept.-Nov.) is 1 to <2 cm. or >5 cm. (0.33 to <0.75 in. or >2 in.)	0.75
	Litter layer thickness in: Winter/spring (Dec.-May) is 1.5 to <3 cm. (0.5 to <1.25 in.) Summer (June-Aug.) is 1 to <2.5 cm. (0.33 to <1 in.) Fall (Sept.-Nov.) is 0.5 to <1 cm. (0.2 to <0.33)	0.5
	Litter layer thickness in: Winter/spring (Dec.-May) is >0 to <1.5 cm. (>0 to <0.5 in.) Summer (June-Aug.) is >0 to <1 cm. (>0 to <0.33 in.) Fall (Sept.-Nov.) is >0 but <0.5 cm. (>0 to <0.2 in.) -OR- If wetland is cultivated, no-till practices are in use.	0.25
	No measurable litter is present in the assessment area. However, the wetland is relatively intact and has vegetation present (or is able to support vegetation) capable of producing detritus; -OR- If wetland is cultivated, minimum or conventional tillage practices are in use.	0.1
	There is no detritus present, and the wetland has been altered or eliminated (as from urbanization) so that there is no potential for recovery.	0

Sedimentation in the Wetland

Where to Measure

Sediment is to be measured within the wetland. The entire wetland assessment area should be evaluated, and representative sites selected for sampling. Measurements taken should be evaluated and averaged in order to assign the typical or representative conditions for the wetland.

It will be necessary to predict the most likely place to find sediment in the wetland. This will provide an accurate measurement with the least amount of effort. Attention should focus on identifying sources of greatest sediment yield and points where runoff will be the greatest. If parts or all of the adjacent uplands are cropped, or have been cropped in the past, it is likely that areas in the wetland with the greatest deposition of sediment will be adjacent to those cropped uplands. Points where ephemeral drainages enter the wetland from adjacent uplands will also likely exhibit the greatest deposition of sediment, especially if the uplands are cropped.

When to Measure

Measurement of sediment can be taken at any time during the assessment procedure. For efficient use of time, it is best to collect measurements in conjunction with the delineation procedure, or in conjunction with collecting data for the $V_{detritus}$, V_{pore}, and V_{som} variables.

What and How to Measure

Sediment is soil material displaced by wind and water. In areas of intensive agricultural production, sediment deposition in low areas such as slope wetlands is common. In many instances, culturally accelerated sedimentation is easily discernible. There are times, however, when sediment deposition may not be as easily identifiable.

Visual observations of the wetland area can provide clues as to recent and/or historic, culturally accelerated deposition of sediment. A few of the more common trademarks to look for include: small, stabilized deltas or sediment fans; small, dune-like drifts from windblown deposits; sediment staining of or thin silt deposits on detritus; accumulations of sediment along plant stems; and, partial to complete burial of plant crowns, stems, detritus, and other debris.

<u>Preferred Method</u>
A spade can be used to dig a hole and extract a vertical slab of soil. The slab should extend to a depth of 16 inches or more. In certain instances, particularly if the site is inundated with water, a soil probe (preferably one with a 1.5 inch diameter tube) can be used to extract a sample. When working with coarse textured soils (loamy sands and coarser), a soil probe may not work. A spade or hand auger should be used in these situations (although sediment is usually harder to detect in an auger sample).

Color and textural differences in the surface layer are often good indicators of sediment deposition. Sediment overlying an “A” horizon is usually lighter colored than the “A” horizon. A fairly narrow, definitive boundary between the two layers may also be observed. In many situations, the overlying sediment will feel gritty compared to the underlying “A” horizon. This is due to the deposition of more sand-sized particles during overland flow/runoff events and removal of more of the silt and clay. When the boundary between the two layers is determined, the thickness of the overlying sediment is measured and recorded as sediment delivered to the wetland. (Note: The presence of calcium carbonate, or lime, in the sediment layer is not a reliable indicator of deposition. Slope wetlands are groundwater discharge wetlands and thus are typically calcareous in their natural state.)

Alternate Method
There may be situations when it is evident or suspected that there has been some delivery of sediment to the wetland, but a determination can not be made based on field observations. Consult the local soil survey and see if the assessment area has been delineated as a separate mapping unit. If it has, it may be possible to compare the thickness of the "A" horizon for that soil in the survey to that observed on site. This will only work if an abrupt (or other readily discernible) boundary between the "A" and "B" horizons is observed. The difference between the average thickness of the "A" horizon observed on site and that reported in the soil survey could be used to estimate the amount of sedimentation that has occurred in the assessment area.

If none of the above provide a reasonable measure of sedimentation, best professional judgment, based on surficial observations, should be used.

What to Record

Representative or Average Thickness of Sediment in the Wetland ____________in.

Other Visual Observations: ____

____

____

____

V_{sed}: Sedimentation in the Wetland

Model Variable	Measurement or Condition	Index
DEFINITION: The extent of recent and/or historic, culturally accelerated sediment delivered to the wetland (as from human activities, including agriculture). **NOTE:** This variable assesses excess sediment accumulation within the wetland, using direct measurements or visual observations. Certain practices, such as grassed waterways (new construction), **may** redistribute and/or remove sediment from the wetland area during the shaping process. In instances where this happens, **and** where the pre-project rating is less than 0.5, assign a post-project rating of 0.5.	No visual evidence of accelerated sediment delivery to wetland.	1.0
	Minor surficial evidence of sediment delivery to the wetland, primarily along the margin (such as minor accumulations of sediment in the form of small, stabilized deltas, sediment fans, or drift deposits from windblown sediments), -AND/OR- Visual observation indicates average deposition thickness in wetland at <3 inches.	0.75
	Surficial evidence of sediment delivery through most of the wetland (such as sediment staining of or silt deposits on detritus, or slight accumulations of sediment along plant stems); -OR- Tillage through buffer to the outer edge of wetland (<50 percent of wetland has been tilled), -AND/OR- Visual observation indicates average deposition thickness in wetland at 3 to <6 inches.	0.5
	Surficial evidence of sediment delivery through most of the wetland [such as partial burial (25 to 75 percent) of detritus, or burial of plant crowns and partial burial of stems]; -OR- Tillage through buffer and partial or complete tillage through wetland (≥50 percent of area has been tilled), -AND/OR- Visual observation indicates average deposition thickness in wetland at 6 to <9 inches.	0.25
	Significant sediment delivery to the wetland, as indicated by nearly complete (>75 percent) burial of detritus and/or vegetation in wetland. Presence of zones of sediment deposition, such as deltas, sediment fans, or drift deposits, common throughout wetland. Ephemeral or perennial gullies may be present on uplands adjacent to wetland. Best management practices lacking to control sediment delivery, -AND/OR- Visual observation indicates average deposition thickness in wetland at 9 to 12 inches.	0.1
	Pronounced rise in bottom elevation of wetland due to accelerated sediment delivery from cultural sources such as agriculture or urbanization has converted the area to upland.	0

Soil Organic Matter

Soil organic matter content of wetland soils directly influence the ability of the soil, and hence wetland, to retain and release elements and compounds. Soil texture and organic matter content in the upper part of the soil profile affect the ability of the soil to perform this function.

Where to Measure

Soil organic matter content is to be evaluated/measured within the wetland. The wetland assessment area should be evaluated and a representative site selected for sampling. Site selection will depend upon the size and the uniformity of the wetland area. In most situations, the soils within a slope wetland will vary only slightly from the wetland boundary to the bottom of the wetland. A site approximately midway between these two points will normally suffice. Measurements taken should reflect the typical or representative conditions for the wetland.

When to Measure

Evaluation of soil properties for determination of organic matter content can be taken at any time during the assessment procedure. For efficient use of time, it is best to collect measurements in conjunction with the delineation procedure, or in conjunction with collecting data for the $V_{detritus}$, V_{pore}, and V_{sed} variables.

What and How to Measure

Soil properties of concern when evaluating this variable are texture and organic matter content. Begin by digging a hole and extracting a vertical slab of soil. The slab should extend to a depth of at least 16 inches. In certain instances, particularly if the site is inundated with water, a soil probe (preferably one with a 1.5-inch diameter tube) can be used to extract a sample. When working with coarse textured soils (loamy sands and coarser), a soil probe may not work. A spade or hand auger should be used in these situations.

The extracted sample should be examined in a moist state, and not wet (saturated) or dry. Determine whether the texture of the 0 to 12-inch surface layer is sandy (textures of loamy fine sand or coarser) or loamy/clayey (textures of sandy loam and finer). If the texture of this layer is loamy or clayey, record this and use the 0 to 12-inch layer for the next step. If the texture is sandy, record this and use the 0 to 6-inch layer for the next step.

Using the Munsell Soil Color Charts, examine the colors of the layer identified above (the 0 to 12-inch layer for loamy or clayey soils, or the 0 to 6-inch layer for sandy soils). Record the hue, value, and chroma. If the color varies within the observed depth, record the dominant color (the color that occurs in 50% or more of the layer). (In the case of sandy soils, check for neutral colors in the A horizon and note whether there is a darker colored A horizon below and contiguous to the surface layer within the upper 6 inches.)

List the hydric soil indicator used to identify the hydric soil if found in the publication, Field Indicators of Hydric Soils in the United States. If EDTA is used for determining the level of soil organic matter in the field, use the field method outlined by R. A. Bowman, USDA-ARS, Akron, CO.

What to Record

Texture of A Horizon:

0 to 6-inch Depth ________________

6 to 12-inch Depth ________________

Soil Color

Hue __________

Value __________

Chroma __________

Is a darker A horizon contiguous below 6 inches? __________

Percent Organic Matter (EDTA Method, if used) __________

V_{som}: Soil Organic Matter (Loamy/Clayey)		
Model Variable	**Measurement or Condition**	**Index**
DEFINITION: The amount of organic matter in wetland soils affects their ability to cycle elements and nutrients. **NOTE:** The conditions specified are for **loamy and clayey soils** (i.e. soils with textures of sandy loam and finer). For soils with sandy textures (loamy fine sand and coarser), refer to the description of this variable on the next page.	Soil organic matter content is $\geq$5 percent (measured or from published literature), -AND/OR- Soil colors in 50 percent of more of the upper 12 inches have neutral hue and value of 2/ or 3/; or any hue with value of 2.5 or less and chroma 1 or less.	1.0
	Soil organic matter is 3 to <5 percent, -AND/OR- Soil colors in 50% or more of the upper 12 inches have any hue with value of 3 and chroma of 1, or value of 2 and chroma of 2.	0.75
	Soil organic matter content is 1.5 to 3 percent, -AND/OR- Soil colors in 50 percent of more of the upper 12 inches have neutral hue and value of 4/; or any hue with value of 3 and chroma of 2, or value of 4 and chroma of 1.	0.5
	(No conditions for this index have been established.)	0.25
	Soil organic matter content is <1.5 percent, -AND/OR- Soil colors in 50 percent of more of the upper 12 inches have any hue with value $\geq$4 and chroma $\geq$2.	0.1
	The surface lacks soil or natural substrate properties (such as with asphalt, concrete, or buildings).	0

V_{som}: Soil Organic Matter (Sandy)

Model Variable	Measurement or Condition	Index
NOTE: The conditions specified are for sandy soils (i.e. soils with textures of loamy fine sand and coarser).	Soil organic matter content is ≥2 percent (measured or from published literature), -AND/OR- Mineral soil colors in the upper 6 inches have: a neutral hue, with value of 2 or 3, or; a value of 2 or less and chroma of I or less, and no A horizon with darker colors occurs immediately or contiguously below 6 inches. (Indicator: The assessment area has not been drained or cropped.)	1.0
	(No conditions for this index have been established.)	0.75
	Soil organic matter content is 0.5 to 2 percent (measured or from published literature), -AND/OR- Mineral soil colors in the upper 6 inches have value of 3 or 4 and chroma of 2 or less. (Indicator: The assessment area has been partially drained, or there is evidence of intermittent or historical tillage.)	0.5
	(No conditions for this index have been established.)	0.25
	Soil organic matter content is <0.5 percent (measured or from published literature), -AND/OR- Mineral soil colors in the upper 6 inches have value >4 and/or chroma of >2. (Indicator: The assessment area has been “effectively” drained and frequently tilled.)	0.1
	The surface lacks soil or natural substrate properties (such as with asphalt, concrete, or buildings).	0

Soil Pores

Where to Measure

Soil pores will be measured within the wetland. The entire wetland assessment area should be evaluated, and representative sites selected for sampling. If the wetland assessment area has been partially tilled (in other words, part of the area is or has been tilled and part hasn't), evaluations should be made in both tilled and untilled portions of the wetland. Site selection will depend upon the size and the uniformity of the wetland area. In most situations, the soils within an undisturbed slope wetland will vary only slightly from the wetland boundary to the bottom of the wetland. A site approximately midway between these two points will normally suffice. Measurements taken should be evaluated and averaged in order to assign the typical or representative conditions for the wetland.

When to Measure

Soil pores can be measured at any time during the assessment procedure. For efficient use of time, it is best to collect measurements in conjunction with the delineation procedure, or in conjunction with collecting data for the $V_{detritus}$, V_{sed}, and V_{som} variables.

What and How to Measure

Pores are naturally occurring voids in the soil which facilitate the occurrence and movement of air and water. The number, size, and continuity of pores in soil may vary considerably from an undisturbed site to one that is or has been cultivated. In assessing this variable, look for topographical highs and lows in the wetland, remnant crop residues, or other features that may indicate past tillage.

A spade can be used to dig a hole and extract a vertical slab of soil. The slab should extend to a depth of 16 inches. In many instances, particularly if the site is inundated with water, a soil probe (preferably one with a 1.5-inch diameter tube) can be used to extract a sample. When working with coarse textured soils (loamy sands and coarser), a soil probe may not work.

Apply a moderate thud to the back of the spade to help show the natural structure cleavage of the soil. Record the presence or absence of an Ap horizon (plow layer), or other evidence of past tillage. Look for smooth, horizontal layer(s) in this zone that could indicate presence of a plow layer. Observe the 4 to 10-inch layer and pay special attention to evidence of a plow pan. Horizontally deflected root growth is a good indicator of a highly compacted layer (plow pan). Record any observations from this zone.

Examine the slab of soil and note the size, shape, and grade (distinctness) of the soil peds in the A horizon. Note if the structure parts to medium and fine granular, as well as the size of any blocks and/or prisms. Record the size, grade, and type of structure present in the A horizon. (Note: If using a soil probe with a 1.5-inch diameter tube, larger structural units such as blocks and prisms may not be easily observed.)

Examine horizontal ped surfaces for tubular pores. Concentrate on the layer with the least amount of pores and the most compaction if an Ap horizon is present. Count the number of very fine and fine pores in a square centimeter and the number of medium and coarse pores in a square decimeter. Also examine the pores to determine their continuity. Record the number of pores and their continuity. (Note: Plant roots are a surrogate for pores. Abundance and distribution of roots in the A horizon can be used to indicate pore abundance.)

Determine rupture resistance (consistence) in the upper 16 inches of the soil. Obtain a soil ped (approximately one-inch cube) that has not been compressed or deformed. Crush it between your forefinger and thumb, noting the strength needed to deform or rupture it. Record the effort needed to crush the ped as very friable (very slight force needed), friable (slight force needed), firm (moderate force needed), or very firm (strong force needed). Record the most resistant measurement found within the upper 16 inches of the soil. (Note: If the assessment site is tilled, this will probably be in a 4 inch thick layer found just below the tillage zone. This may extend to a depth of 12 inches.)

What to Record

Primary Indicators

Evidence of Past Tillage (yes/no) _______________

Ap Horizon Present (yes/no) _______________

Evidence of Plow Pan (yes/no) _______________

Secondary Indicators

Texture of A Horizon

0 to 6-inch Depth ____________

6 to 12-inch Depth ____________

Soil Structure

Size ____________________

Type ____________________

Grade ____________________

Soil Pores

Number _______________

Continuity ____________________

Rupture Resistance ____________________

V_{pore}: Soil Pores		
Model Variable	**Measurement or Condition**	**Index**
DEFINITION: The physical integrity of the soil in the **surface layer and the upper part of the subsoil**, based on the number and continuity of pores, the type, grade, and size of soil structure, and moist soil consistence (rupture resistance). **NOTE:** The conditions specified are for loamy and clayey soils (i.e. soils with textures of sandy loam and finer). For soils with sandy textures (loamy fine sand and coarser), refer to the description of this variable on page 33. Refer to the Soil Quality Index (SQI) rating guide on the following page.	Soil Quality Index (SQI) $\geq$ 8. (Indicator: No evidence of an Ap horizon, or plow layer, within the hydric soil boundary.)	1.0
	Soil Quality Index (SQI) is 6 or 7. (Indicator: An Ap horizon is visible in part or all of wetland. The Ap horizon may be clearly visible or may be obscure. Wetland has not been tilled for 10 or more years, or has been restored for $\geq$20 years.)	0.75
	Soil Quality Index (SQI) is 4 or 5. (Indicator: An Ap horizon is present in the wetland. Wetland is partially tilled, or has been restored for <20 years.)	0.5
	(No conditions for this index have been established.)	0.25
	Soil Quality Index (SQI) is 3 or less. {Indicator: A plow pan is present in the wetland, evidenced by roots growing horizontally along the pan rather than vertically through it. (Wetland is tilled throughout most years.)}	0.1
	The substrate is a non-porous medium (such as asphalt or concrete).	0

Table 1. Soil Quality Index (SQI) Rating Guide

Soil Pores SQI Rating	
Descriptive Rating	**Numerical Rating**
Many fine and very fine, continuous pores	3
Common, continuous and discontinuous pores	2
Few discontinuous pores	1

Soil Structure SQI Rating	
Descriptive Rating	**Numerical Rating**
Weak to moderate prismatic, parting to moderate to strong angular or subangular blocky, parting to moderate or strong granular	3
Weak to moderate grades of subangular blocky and granular	2
Massive, or weak to strong coarse and very coarse subangular blocky, or medium or coarse plate-like below a plow layer (plow pan)	1

Rupture Resistance SQI Rating	
Descriptive Rating	**Numerical Rating**
Friable to very friable	3
Friable to firm	2
Very firm and harder	1

Soil Quality Index (SQI) rating = soil pore rating + soil structure rating + rupture resistance rating. Plug the resulting value into the table on the previous page.

V_{pore}: Soil Pores		
Model Variable	**Measurement or Condition**	**Index**
NOTE: Use this condition for soils with sandy textures (loamy fine sand and coarser).	Many fine and very fine, continuous pores (if observable), -AND- Soil structure is one or more of the following: weak medium or fine subangular blocky, and/or; moderate or strong granular, -AND- Rupture resistance is very friable or loose. {Indicator: No evidence of an Ap horizon, or plow layer, within the hydric soil boundary.}	1.0
	(No conditions for this index have been established.)	0.75
	Common fine and very fine, continuous and discontinuous pores (if observable), -AND- Soil structure is weak subangular blocky and or weak granular, -AND- Rupture resistance is friable. {Indicator: An Ap horizon is present in wetland. Wetland is partially tilled or has been restored for <20 years.}	0.5
	(No conditions for this index have been established.)	0.25
	Few fine and very fine discontinuous pores (if observable), -AND- Soil structure is one or more of the following: weak coarse subangular blocky, and/or; medium or coarse plate-like, below a plow layer, and/or; massive (structureless), -AND- Rupture resistance is firm or harder. {Indicator: An Ap horizon is present throughout the wetland. Wetland is tilled most years. A plow pan is present, as evidenced by roots growing horizontally along the pan, rather than vertically through it.}	0.1
	The substrate is a non-porous medium (such as asphalt or concrete).	0

Buffer Condition, Continuity, and Width

The buffer is considered the zone of transition between the jurisdictional wetland boundary and the surrounding upland landscape. It is, technically speaking, part of the upland and not the wetland. Thus, establishment of the jurisdictional wetland boundary, and determination of the wetland assessment area, is necessary in order to determine the buffer area. There are three components to the buffer that are to be evaluated and measured. These components are condition, continuity, and width. They are discussed in more detail below.

Where to Measure

For purposes of evaluation using this model, the buffer zone should be considered as the area from the wetland boundary outward to a distance of 100 feet. After the wetland assessment area is established, the buffer zone adjacent to the assessment area should be established and evaluated. An imaginary line can be drawn on the landscape to establish this area or, if desired, flags can be placed at the wetland boundary and 100 feet out from that boundary.

When to Measure

Evaluation of the condition, continuity, and width of the buffer can be done at any time during the assessment procedure. For efficient use of time, it is best to collect measurements for these variables simultaneously, after establishment of the jurisdictional wetland boundary.

What and How to Measure

Visual observations and actual measurements should be made in order to score this variable. In most situations, the 100-foot buffer zone will either be in permanent vegetation, tilled, or a combination of these.

<u>Buffer Continuity</u>
When assessing this variable, the buffer on all sides of the wetland assessment area should be considered. The evaluation of buffer continuity involves determining what percent of the assessment area is bounded by permanent vegetation. If permanent vegetation is continuous adjacent to the wetland, then continuity would be 100 percent. If part of the buffer zone is tilled up to the edge of the wetland, then continuity will be less than 100 percent. Measurements can be taken along the length of the wetland (such as number of feet of permanent vegetation compared to total length of wetland) to determine continuity. Best professional judgement can also be employed by the evaluator to determine percent continuity when the buffer is less than one hundred percent continuous.

<u>Buffer Width</u>
The width of the permanently vegetated buffer zone can be determined by field measurements. The buffer on all sides of the assessment area should be considered. If the width of permanently vegetated buffer is variable along the length of the assessment area and is less than 100 feet wide, measurements should be taken and averaged and best professional judgement used to determine an average width.

<u>Buffer Condition</u>
Buffer condition considers the state of the 100-foot zone adjacent to the wetland assessment area. This zone may be permanently vegetated with native species, introduced species, or both; it may be cultivated; or, it may be a combination of the two. If the entire buffer zone is in permanent

vegetation, visually estimate species composition and vegetative canopy cover and record. This will be the basis for figuring buffer condition. If tillage occurs within 100 feet of the wetland, both the permanently vegetated part and the tilled part of the buffer zone will require evaluation. Estimate canopy cover and species composition (native, introduced, or mixed) in the vegetated part. Determine practices (type of tillage) in use on the tilled part. In addition, estimate the percent of the buffer zone each of these areas occupies. This can be done when determining width of the permanently vegetated part of the buffer (buffer width).

What to Record

Representative or Average Width of the Buffer in Permanent Vegetation ____________ft.

Percent of Permanently Vegetated Buffer Zone Adjacent to Wetland Assessment Area Disrupted by Tillage __________ % (Subtract this figure from 100% to obtain % continuity.),

or

Percent of Buffer Zone Adjacent to Wetland Assessment Area in Permanent Vegetation __________ % continuity.

Estimated Status of Dominant of Species in Permanently Vegetated part of Buffer (Native, Introduced, or Mixed) __________.

Estimated Percent Canopy Cover of Permanent Vegetation in the Buffer __________ %.

Tillage Operation Used Within Buffer Zone (Type) ____________________________________.

Buffer Condition, Continuity, and Width
(V_{buffer})

Definition: An assessment of the condition, continuity, and width of the permanently vegetated buffer adjacent to the wetland.

Methodology for Rating V_{buffer}: There are three components to the buffer variable. These components are buffer condition, buffer continuity, and buffer width. Buffer continuity and width are interrelated components of the buffer variable. A summary rating has been developed (Table 2) based on various combinations of these two components. Buffer condition is evaluated independently based on conditions identified in Table 3. The following steps should simplify the procedure for calculating an index value for this variable.

Step 1. Determine a rating for buffer continuity/width from Table 2. This value, referred to as B_1, can be found where the intersection of the average width of permanently vegetated buffer (width) and continuity of permanently vegetated buffer (cont.) occurs.

Step 2. Determine a rating for buffer condition (B_2) from Table 3. If the 100-foot buffer zone is permanently vegetated, use conditions as described in column (a) to obtain this rating. If part of the 100-foot buffer zone has been tilled, evaluate both the vegetated and tilled portions using conditions described in columns (a) and (b). The approximate width (to the nearest 10 feet), expressed as a decimal, can be used as the percent of total buffer area each of the described conditions occupies since it is based on a 100-foot wide zone (i.e. "x" divided by 100 times 100 equals "x"). The total % of area should equal 100. Use the following equation to arrive at a value for buffer condition (B_2):

$$B_2 = [\text{Col. (a) rating x \% of area}] + [\text{Col. (b) rating x \% of area}].$$

Step 3. Determine an index rating for V_{buffer} using the formula:

$$V_{buffer} = [(B_1) \text{ x } (B_2)]^{1/2}.$$

Note: If there is no permanently vegetated buffer, then the index rating for the variable is 0.

Table 2. Summary Rating for Buffer Continuity and Width (B_1)						
Cont. (%) / Width (Ft.)	100	80-99	60-79	40-59	20-39	1-20
≥100	1.0	.9	.7	.5	.3	.15
75-99	.8	.75	.6	.4	.25	.1
50-74	.6	.5	.5	.3	.2	.1
25-49	.4	.3	.3	.2	.15	.05
10-24	.2	.2	.15	.1	.1	.05
1-9	.1	.1	.1	.05	.05	0

Table 3. Buffer Condition (B_2) Rating Guide		
Measurement or Condition		**Index**
Permanently vegetated part (a):	***Tilled part (b):***	
Native canopy is 90 to 100 percent and consists primarily of perennial herbaceous and woody species.		1.0
Native perennial vegetative canopy present is 75 to 89 percent; -OR- Introduced perennial rhizomatous species (smooth brome, intermediate wheatgrass, etc.) provide the dominant vegetative canopy throughout the buffer.		.75
Native perennial vegetative canopy present is 50 to 74 percent, -OR- Dominant vegetation consists of vigorous, introduced, bunch-type perennials.	No-till practices are used in the buffer area.	.5
Native perennial vegetative canopy present is 25 to 49 percent; -OR- Dominant vegetation consists of native or introduced, bunch-type, low-vigor perennials.	Minimum till practices are used in the buffer area.	.25
Native perennial vegetative canopy present is 1 to 24 percent.	Conventional tillage is in use in the buffer area.	.1
Native perennial vegetative canopy is < 1 percent.		0

Ratio of Native to Non-Native Species

Where to Measure

Plant species ratio is to be measured within the wetland. The entire wetland assessment area should be considered and evaluated when rating this variable.

When to Measure

Measurement of the ratio between native and non-native species present in a wetland can be taken at any time during the assessment procedure. For efficient use of time, it is best to collect measurements in conjunction with the delineation procedure or in conjunction with collecting data pertaining to vegetation density (V_{pcover}).

What and How to Measure

This measurement needs to take into account the typical inter-seasonal and intra-seasonal conditions of the wetland. Wetlands covered with perennial vegetation are relatively easy to rate. Events such as fire, tillage, extended wet or dry periods, and abrupt changes in precipitation can change the species composition in part or all of the wetland. In these cases, seek additional information and use best professional judgement. Local experts who are familiar with the site may be able to provide useful information.

Rating this variable requires a determination of the percent occurrence of native and non-native species in the wetland. The evaluator has the option of choosing to run a species transect survey through the wetland, or of using visual observations to estimate species composition. Less experienced evaluators may wish to use scientific methods of determining species composition and percentages, such as a point-intercept transect, until experience is gained and the evaluator is confident that visual observations will provide reasonably accurate figures.

<u>Method 1. Transecting the Area</u>
Traverse the wetland assessment area and note the occurrence and distribution of plant species present on the site. An area in perennial vegetation will usually require more time to survey than one that is tilled. If the site is undisturbed, select one or more sites at which to collect transect data. Selection and number of transect sites will depend on the number of significantly different plant communities present in the wetland assessment area, distribution of individual species, and size of the area. A well-distributed native plant community may only require one sampling point, whereas a conglomerate of different plant communities may require more. Also, larger wetland areas may require more sampling points when different plant communities are present. Disturbed sites, such as sites that have been seeded to hayland or pasture species or tilled, may require only a visual determination of specie(s) present. Decide which transect method will work best in the assessment area. Record all species present, identify whether each is a native or non-native, and determine percent composition of each species. In most instances, the four dominant species present will be used to determine a rating for this variable.

<u>Method 2. Visual Observations</u>
Traverse the assessment area and note the occurrence and distribution of plant species present on the site. If the evaluator chooses to use best professional judgement in making a visual survey of the site, thorough coverage of the assessment area is required to obtain a complete list of the plant species present. Unlike transecting, especially when two or more transects are required, visually evaluating the plant community within the wetland should produce only one set of data.

Wetlands that contain segregated plant communities with significantly different components will require more time in the observation process than those wetlands with relatively homogenous communities. Likewise, wetlands with little diversification, such as with introduced species, or monogamous stands of plant species such as cattails, will require little time in the evaluation process. As with the vegetative transect method, record all species present, identify whether each is a native or non-native, and determine percent composition of each species.

What to Record

Species Present On-Site	(N)ative or (I)ntroduced	Percent Composition

Percent Native Species Present On-Site _______%

V_{pratio}: Ratio of Native to Non-Native Species

Model Variable	Measurement or Condition	Index
Definition: The ratio of native to non-native plant species present in the wetland as indicated by the top 4 dominants or by a more extensive species survey.	Native species comprise >80 to 100 percent of all species present in the wetland.	1.0
	Native species comprise >60 to 80 percent of all species present in the wetland.	0.75
	Native species comprise >40 to 60 percent of all species present in the wetland.	0.5
	Native species comprise 15 to 40 percent of all species present in the wetland.	0.25
	Native species comprise 1 to <15 percent of all species present in the wetland; -OR- Lythrum salicaria (Purple Loosestrife) is among the dominant species present; -OR- Single dominant plant species (native or non-native) comprise a monotypic invasive stand within any wetland zone (such as cattails, reed canarygrass, etc.).	0.1
	Wetland unvegetated.	0

Vegetation Density

Where to Measure

Ground cover is to be measured within the wetland. The assessment area should be scouted, and a representative site (or sites) selected for sampling. Ground cover can be relatively contiguous throughout a wetland, or it can be variable. In addition, species composition can be diverse and randomly distributed, or clustered in monocultures (e.g. dense stands of cattails or reed canarygrass). In instances when species composition and density of vegetation present in the assessment area is variable, several sampling points should be selected and averaged in order to capture the variability.

When to Measure

Measurement of vegetative ground cover can be taken at any time during the assessment procedure. For efficient use of time, it is best to collect measurements in conjunction with the delineation procedure or in conjunction with collecting data pertaining to native and non-native species ratios (V_{pratio}). Measurement of this variable will be more difficult during the non-growing season, particularly winter and early spring, due to the disruption of standing vegetation and vegetative remnants by snow, wind, and other climatic factors.

What and How to Measure

The evaluation of ground cover needs to be based on the typical inter-seasonal and intra-seasonal conditions of the wetland. Wetlands that are covered with perennial vegetation are easy to rate. Wetlands that are cultivated intermittently may be more difficult to assess. Events such as fire, tillage, extended wet or dry periods, and abrupt changes in precipitation may culminate in a plant cover that is much more or much less than average for the site. In these cases, additional information should be sought and best professional judgement used when assessing the site. Document observations from aerial color slides and infrared photography from the current and previous years. Observations of local experts who may be familiar with the site would also be useful.

Outline the assessment area, either using flags or mentally. Evaluate the plant cover on the entire assessment area, but not beyond. Avoid being thrown off by tillage lines or other pseudo-boundaries.

Look at the wetland from a vantage point to be able to identify areas with significantly more or less cover than the predominant situation. Determine the relative size of each such area by visual estimation or by measurement such as pacing, and record findings. Assess the plant cover on each portion individually, and assign a weighted index score for the wetland as a whole.

If the wetland has been cultivated or otherwise disturbed in a manner that reduces vegetative growth, observe the amount of plant material present on the surface. Record observations on the site. A mental or other comparison of the assessment site and a comparable native site in excellent condition is helpful.

Consider the temporal aspects of vegetative cover. While native wetlands in excellent condition are usually covered with growing vegetation for most of the growing season, plant cover on cultivated sites is widely variable. Best professional judgement is critical for assigning the index score that represents the inter- and intra-seasonal average for the wetland.

What to Record

Is the assessment area in permanent vegetative cover, tilled, or both? ______________________

If both, estimate the percent of the WAA that is permanently vegetated and the percent that is tilled.

Permanently vegetated __________%
Tilled __________%
(These should total 100%)

If permanently vegetated (or the part of the WAA that is permanently vegetated):

How many significantly different vegetative canopies occur on the site? _____________

Estimated ground cover. ____________%

If tilled (or the part of the WAA that is tilled):

What is the frequency of tillage? ______ out of 10 years.

V_{pcover}: Vegetation Density

Methodology for Rating V_{pcover}: If the entire wetland assessment area has a homogenous plant cover or similar use, rate this variable based on the conditions described below. If the area has dual cover types or dual uses (such as when part of the wetland has been tilled and part is intact), either split the wetland into two assessment areas (if this is practical), or evaluate and rate each part of the wetland separately. If the proposed project impacts the entire wetland, the wetland should be considered one assessment area. To determine V_{pcover} for a wetland where dual cover types or uses occur, first determine the percent of the area that is intact and the percent of the area that is tilled or otherwise impacted. Then, rate V_{pcover} for each of these parts. To establish a summary rating for this variable, use the following equation:

$$V_{pcover} = \frac{(\text{\% of area intact x variable index}) + (\text{\% of area tilled x variable index})}{100}$$

Model Variable	Measurement or Condition	Index
DEFINITION: The abundance of actively growing plants throughout the wetland.	Ground cover is >80 to 125 percent, -AND- Wetland is intact (either undisturbed or has not been tilled or otherwise disturbed for 20 years or more).	1.0
	Ground cover is >60 to 80 percent, or >125 percent, -AND- Wetland is intact (either undisturbed or has not been tilled or otherwise disturbed for 20 years or more).	0.75
	Ground cover is >40 to 60 percent, -AND- Wetland is intact (either undisturbed or has not been tilled or otherwise disturbed for 20 years or more); -OR- Wetland is tilled infrequently (20% or less of all years).	0.5
	Ground cover is >20 to 40 percent; -OR- Wetland is tilled occasionally (>20% to <60% of all years). Hydrophytic vegetation normally returns to the site during wet periods when tillage is impossible.	0.25
	Ground cover is 1 to 20 percent; -OR- Wetland is tilled most years (60% or more of all years). Growing hydrophytic vegetation may return to the site during wet periods when tillage is impossible.	0.1
	Plants absent, no ground cover (site is more disturbed than described above).	0

Microtopographic Complexity

Where to Measure

This variable will be measured within the wetland.

When to Measure

Rating of this variable should be done in the field. It can be done at any time during the assessment. If the assessment area requires a survey for determination of surface hydrology alterations, microtopography can be determined from one or more cross-sections of the wetland.

What and How to Measure

Wetland microtopography is one indicator used in the determination of the ability of the wetland to slow the rate of surface water flow. Microtopography considers only the roughness of the surface of the wetland. Other indicators dealing with vegetation (such as V_{pcover}) also aid in retardation of surface flow, and are considered along with microtopography when determining an index of function. When rating this variable, observations should include wetland slope, meanders or other flow path characteristics, high water marks, and distribution of natural surficial variability (such as with hummocks or silt bars). A combination of cross-sectional surveys and measurements of the wetland surface, and best professional judgement on the part of the evaluator, should be employed when evaluating the condition of the wetland when rating this variable. Average annual peak discharge depth can be calculated using methods found in the Engineering Field Manual Chapter 2 (EFM 2), or technical releases 20 or 55 (TR 20 or TR 55). Also note severe disturbances such as channelization.

What to Record

Description of the Distribution and Frequency of Naturally-Occurring Hummocks ________________
____.

Frequency of Meanders, or Changes in the Main Surface Water Flow Path ________________
____

Does the average annual, peak discharge depth exceed the average annual height of the vegetation present (Yes/No)? __________

Other Notes: ____

____

____

____

____

____

V_{micro}: **Microtopographic Complexity**		
Model Variable	**Measurement or Condition**	**Index**
DEFINITION: The microtopographic surface roughness of the wetland.	Natural conditions occur within wetland, -AND- Average annual, storm-based, peak discharge depth does not exceed the average annual height of the vegetation. [Indicator: Main flow path frequently shifts from side to side (meanders) due to changes in cross-sectional shape of the wetland surface; well-distributed, frequently occurring, natural hummocks; gentle changes in slope/topography. If historically cultivated, no prior manipulations present and site has not been tilled for 20 years or more.]	1.0
	(No conditions for this index have been established.)	0.75
	The primary water flow path through the wetland occasionally or rarely shifts from side to side (meanders) due to changes (or lack of) in cross-sectional shape of the wetland surface; poorly distributed natural hummocks; moderate or severe breaks in slope/topography, -AND/OR- Average annual, storm-based, peak discharge depth exceeds the average annual height of the vegetation. [Indicators: Area is tilled no greater than 20% of all years; waterways or other surface manipulations >20 years old may be present.]	0.5
	(No conditions for this index have been established.)	0.25
	The wetland retains little or no of its original topographical characteristics due to frequent tillage (20% or more of all years) or other manipulations which have a smoothing effect on the surface; -OR- Area has been channeled and is vegetated, without installation of water bars or other attributes that would slow the flow of surface water. *(NOTE: If water bars or other types of surficial roughness are part of the design of grass waterways, use an index rating of 0.25 for this variable.)*	0.1
	Area has been channeled and is not vegetated, or has been obliterated by urbanization (i.e. paved, filled and leveled, etc.)	0

Source Area of Flow Intercepted by Wetland

Where to Measure

This variable reflects the catchment or watershed of the wetland. Measurement of this variable will be compared to the unaltered watershed area of the wetland.

When to Measure

These measurements can be taken at any time during the assessment, but for efficiency, could be done in the office and checked in the field. If small wetlands on flatter topography do not show contour lines on the USGS maps, sketch the wetland watershed on an aerial photo in the field.

What and How to Measure

Review aerial photography, USGS quad sheets, scope and effect maps and NWI maps. Outline the original (natural or unaltered) watershed area on a topographic map. Note and document any surface alterations (roads, surface ditches, terraces, etc.), irrigation systems, and subsurface alterations (tile, wells, etc.) within 500 feet, or within the watershed area of, the wetland. Estimate the amount of watershed area that has been structurally altered to prevent flow to wetland (such as roads without culverts, terraces, etc.). Note and document wetland subclass. From the USGS quad map, delineate the original (natural or unaltered) watershed area.

If the office review can determine that the watershed area has been altered, determine the amount of watershed area that has been structurally altered to prevent or add flow to the wetland. In most cases, the variable index is calculated based on % of watershed from which water is added to or prevented from reaching the wetland. (If 10% of the watershed has been "cut off", or if 10% additional watershed has been added to the source area, the index rating would be a 0.9).

In the field, verify all alterations noted during the off-site review and document any additional alteration found during the field investigation.

What to Record

Type and effect of surface alteration(s) within watershed ________________________________

____

Type and effect of subsurface alteration(s) within watershed _____________________________

____

Change in NWI wetland subclass (YES or NO) ___________

Addition to, or subtraction from, original watershed area ________%

V_{source}: Source Area of Flow Intercepted by Wetland		
Model Variable	**Measurement or Condition**	**Index**
DEFINITION: The area surrounding a wetland that defines the watershed area of that wetland. **NOTE:** The entire watershed area should be considered when determining the functional index for this variable.	No surface or subsurface alterations occur within upland watershed source area. *(NOTE: Surface alterations include structures designed to impound water, such as dams and terraces, or roads. Subsurface alterations include tile drains and ditches. No additions or inputs, such as from irrigation and associated practices or terrace outlets, are present.)*	1.0
	Surface alterations occur within the upland watershed source area which impacts overland flow into wetland (such as terraces or road right-of-ways, with culverts allowing passage of water). Less than 20 percent of watershed area is impacted, -AND- no subsurface alterations or additions (identified in 1.0, above) are present.	0.75
	Surface alterations occur within the upland watershed source area which impacts overland flow into wetland (such as terraces, or road right-of-ways which partially divert the flow of water to the wetland). Greater than 20 to 50 percent of watershed area is impacted, -AND- no subsurface alterations or additions (identified in 1.0, above) are present.	0.5
	The dominant surface and subsurface flow path of water in the upland watershed source area has been altered, thus affecting the flow of water to the wetland (such as by tiling, terraces, or irrigation return). Greater than 50 to 95 percent of the watershed area is impacted, -AND- The alteration(s) does not change the wetland subclass.	0.25
	The dominant surface and subsurface flow path of water in the upland watershed source area has been altered, thus affecting the flow of water to the wetland (such as by tiling, terraces, or irrigation return). Greater than 50 to 95 percent of the watershed area is impacted, -AND- The alteration(s) changes the wetland subclass.	0.1
	Upland watershed source area extremely altered such that 95% or more of all water flow to wetland has been eliminated (such as from urbanization).	0

Subsurface and Surface Hydrology Alterations

Alterations to wetland hydrology have an impact on the surface and subsurface hydrologic regime, or flow network, within the wetland. These variables assess the impacts that subsurface (V_{subalt}) and surface ($V_{surfalt}$) alterations have on wetland hydrology.

Where to Measure

Subsurface alterations (V_{subalt}) include any subsurface drainage feature that has an impact on wetland subsurface hydrology. These features may occur within the wetland assessment area, or they may occur outside the jurisdictional wetland boundary but close enough to have an impact on hydrology within the wetland. Measurement of surface alterations ($V_{surfalt}$) is done within the wetland assessment area. Scope and effect documentation may be used to determine extent of drainage in conjunction with field verification.

When to Measure

These measurements can be taken at any time during the assessment procedure, but for efficiency, could be performed in conjunction with delineation of the wetland assessment area. It is best to evaluate these variables simultaneously. Distances to drainage features may be measured from aerial photography prior to going to the field.

What and How to Measure

Alterations to wetland hydrology can occur in several forms. The most common manipulations are tiling, ditching, and fill placement within the wetland. These manipulations impact lateral movement of subsurface flow (or saturation) and/or surface water flow, and generally result in a decrease of water to the wetland. Approved surveying methods and equipment should be used to determine elevations and distances.

The wetland assessment area should be scouted, along with the adjacent non-wetland area, and evidence of the presence of artificial drainage and/or fill noted. Depending on the type of manipulation that has been identified and whether it is a subsurface or surface alteration or both, follow the steps outlined below.

<u>Subsurface Hydrology Alterations</u>
Elevations of buried subsurface drainage features (tile) should be determined as follows:

1. Determine the tile size from scope & effect or local information.
2. Determine the shortest distance between the tile and the wetland.
3. Determine the depth the tile is below the ground surface with the tile probe.
4. Shoot the elevation at this location and subtract the depth to tile and the tile diameter from the ground elevation.
5. Shoot the elevation of the wetland boundary and calculate the depth to tile below the wetland boundary by subtracting the elevation difference between the ground at the tile location and the wetland boundary from the depth calculated in step 4.

Elevations of surface drainage features (road ditches, accelerated gullies, etc.) should be determined as follows:

1. Determine the shortest distance between the surface drainage feature and the wetland.
2. Shoot the elevation of the lowest point in the surface drainage feature at this

distance.

Surface Hydrology Alterations

Office Procedures:

1. From USGS topographic map determine wetland watershed (use same procedures as in V_{source}).
2. Using procedures outlined in the Engineering Field Manual, Section 2, calculate the peak discharge for the 5- and 10-year, 24 hour storm.

Field Procedures:

1. Shoot sufficient elevations of the surface alterations to determine cross-sectional area.
2. Shoot sufficient elevations to determine slope of alteration.
3. Using the cross-section, slope, and storm peak discharge information to determine if constructed channel will handle the storm discharges (either calculate the channels capacity manually or use the waterway design capacity tables found in the Engineering Field Manual, Section 7).

What to Record

Type of Alteration Present (Subsurface, Surface, Both, or None) ____________________

If a Subsurface Alteration is present:

Type of subsurface alteration(s) ____

Distance from wetland edge to subsurface alteration ________________ ft.

Elevation of bottom of wetland __________ Elevation of wetland boundary __________

Invert elevation of subsurface alteration ________________

Wetland soil map unit name ______________ Upland soil map unit name ______________

Distances from lateral effects table or DRAIN program ____________________ ft.

If a Surface Alteration is present:

Type of surface alteration(s) ____

Distance from wetland edge to surface alteration _________________ ft.

Elevation of bottom of wetland __________ Invert elevation of surface alteration __________

Surface alteration cross-sectional area ________________ ft^2.

Slope of surface alteration _______________

Percent of wetland affected by fill __________%

Percent of wetland affected by dugout __________%

<table>
<tr><th colspan="3">V_{subalt}: Subsurface Hydrology Alterations</th></tr>
<tr><th>Model Variable</th><th>Measurement or Condition</th><th>Index</th></tr>
<tr><td rowspan="6">Definition: Presence or absence of a constructed subsurface drainage feature affecting the wetland ground water surface elevation.

NOTE: The impact of a subsurface drain on the wetland is determined by its relative elevation and distance from the wetland.</td><td>No subsurface drain present;
-OR-
If there is a nearby subsurface drainage feature, the distance to such feature is equal to or greater than that identified as the lateral effect in the DRAIN program or the approved county lateral effect table for the soil type.</td><td>1.0</td></tr>
<tr><td>The distance to a nearby subsurface drainage feature is less than the lateral effect distance identified, with a corresponding impact to the wetland size and/or width of less than or equal to 25 percent;
-OR-
Development of the assessment area for livestock water (spring development) is planned.</td><td>0.75</td></tr>
<tr><td>The distance to a nearby subsurface drainage feature is less than the lateral effect distance identified, with a corresponding impact to the wetland size and/or width of greater than or equal to 25 to less than or equal to 50 percent.</td><td>0.5</td></tr>
<tr><td>The distance to a nearby subsurface drainage feature is less than the lateral effect distance identified, with a corresponding impact to the wetland size and/or width of 50.1 to 75 percent.</td><td>0.25</td></tr>
<tr><td>Surface (2 feet or greater in depth) <u>or</u> subsurface drainage feature within wetland or close enough to impact the wetland size and/or width greater than 75 percent; saturated conditions have been severely impacted but still occur seasonally.</td><td>0.1</td></tr>
<tr><td>Saturated conditions non-existent (completely drained).</td><td>0</td></tr>
</table>

$V_{surfalt}$: Surface Hydrology Alterations		
Model Variable	**Measurement or Condition**	**Index**
Definition: Presence of a constructed surface drainage feature or fill within the wetland. Depth of the surface drain, and depth of fill within the wetland, impacts wetland ground water surface elevation and movement of surface water through the wetland.	No surface drains or fills present.	1.0
	Fill exists within the wetland but affects less than 10 percent of the wetland; -OR- A dugout or dam exists within the wetland but affects less than 10 percent of the wetland area.	0.75
	A surface drain or gullies exist within the wetland, but are less than 1 foot in depth; -OR- Fill exists within the wetland and affects more than 10 percent, but less than 50 percent, of the wetland.	0.5
	A surface drain or gullies exist within the wetland, and are greater than 1 foot in depth, or the natural meandering flow path has been straightened, and out of bank flow will occur for a 5 year, 24 hour storm; -OR- A constructed (grassed) waterway occurs or is planned within the wetland, and is designed to maintain the natural meandering flow path; -OR- Fill or an excavation (pit) exists within the wetland and affects 50 percent or more of the wetland area.	0.25
	A surface drain exists within the wetland that is greater than 1 foot in depth, or the natural meandering flow path has been straightened, and out of bank flow will **NOT** occur for a 10 year, 24 hour storm; -OR- Fill exists within the wetland and affects 50 percent or more of the wetland area.	0.1
	Armored or lined channel **or** wetland completely filled.	0

Upland Use

Where to Measure

Upland use refers to the land use within the wetland watershed area (the area that contributes to the wetland hydrology), excluding the wetland. For evaluation of this variable, the dominant land use within this area will be noted.

When to Measure

Information on present land use is needed to accurately measure and determine the condition of this variable. The land use in the wetland watershed area can be checked in the office from aerial photography and other maps, but will need to be verified in the field. The observation of land use condition may vary by season and is subject to best professional judgement during some time periods.

What and How to Measure

This variable considers a disturbance gradient from well-managed native prairie to an impervious surface such as is found with urbanization. Type of tillage, cropping system, haying, level of grazing management, amount of bare ground and composition of species present will need to be observed. Thickness of sediment within the wetland may provide an indication of the past management of the upland. Information on best management practices in use should be noted.

Upland use categories considered in this variable include the following:

- Permanent native or non-native vegetation; grazed; well managed or under some system of grazing management
- Idle non-native grassland
- Permanent hayland
- Cropland, rotations, and type of tillage
- Other disturbances (urbanization)

What to Record

Dominant Upland Land Cover Types (up to 3), Approximate Percent of Area, and Use (such as idle, grazed seasonally, hayland, etc.)

1. ____

2. ____

3. ____

Level of Management ____

Cropland Rotation ____

Tillage in Use ____

Other Notes [such as evidence of accelerated erosion, excessive (>50%) bare ground, etc.] ___

V_{upuse}: Upland Use

This variable attempts to rate the use of the majority of the upland within the wetland watershed. To do this, a maximum of three upland use types should be considered. Visual observations, aerial photography, local specialists, or other sources should be used to determine the three dominant land types and their approximate percentage occurrence (to the nearest 10 percent) in the landscape. The index value for each condition can be found in the table below. Numbers can be inserted in the following equation to calculate a relative value for this variable.

$$\frac{[\text{Land use 1 (\% area) x Index value}] + [\text{Land use 2 (\% area) x Index value}] + [\text{Land use 3 (\% area) x Index value}]}{\text{Sum \% area}}$$

If two-thirds or more of the upland watershed area is of one or two cover types, score this variable based on those types.

Model Variable	Measurement or Condition	Index
Definition: The most representative use of the upland watershed area, based on at least two-thirds of its total area.	Well managed, permanently vegetated native prairie. Management allows for adequate plant recovery time between grazing periods.	1.0
	Permanent vegetation under a system of management such as: Native species under season-long grazing with moderate use; -OR- Idle non-native grassland; -OR- Permanent native or non-native hayland.	0.75
	Permanent native or non-native pasture which has been historically over-grazed, with some (<50%) bare ground and low plant vigor; -OR- No-till, high residue crops in a grass/legume rotation.	0.5
	Permanent native or non-native pasture which has been severely over-grazed, with significant (<50%) bare ground, low plant vigor, and evidence of soil erosion; -OR- No-till, low residue crops, or continuous minimum till, high residue crops.	0.25
	Conventional tillage cropland; -OR- Inputs/overflow from cultural activities mingled with green space such as farmsteads or urbanized areas.	0.1
	Urban, semi-pervious, or impervious surface resulting in maximum overland flow and a high rate of delivery to the wetland; negligible green space.	0.0

Section IV. Forms and Tables

Form 1. Variable Score Field Form

Field Office ____________________
County ________________
Date _______________

Producer/Landowner ________________
Assessment Area ID. ________________
(If more than one WAA)
Wetland Acres (Pre-) __________
Wetland Acres (Post-) __________

Variable	Measurement Results	Discussion	Variable Score	
			Pre-project	Post-project
$V_{detritus}$: Detritus				
V_{sed}: Sedimentation in the Wetland				
V_{pore}: Soil Pores				
V_{som}: Soil Organic Matter				
V_{buffer}: Buffer Condition, Continuity, and Width				
V_{pratio}: Ratio of Native to Non-Native Species				
V_{pcover}: Vegetation Density				
V_{micro}: Microtopographic Complexity				
V_{source}: Source Area of Overland Flow				
V_{subalt}: Subsurface Hydrology Alterations				
$V_{surfalt}$: Surface Hydrology Alterations				
V_{upuse}: Upland Use				

Form 2. Functional Capacity Index (FCI) Score Field Form

1.0 Moderation of Groundwater Flow

Index of Function = $\{V_{subalt} \times [(V_{source} + V_{upuse}) /2 + (V_{pore} + V_{pcover}) /2] /2\}^{1/2}$

Pre-Project/ Mitigation	= {_______ x [(_______ + _______) /2 + (_______ + _______) /2] /2}$^{1/2}$
Post-Project/ Mitigation	= {_______ x [(_______ + _______) /2 + (_______ + _______) /2] /2}$^{1/2}$

INDEX OF FUNCTION:

[Pre-Project/Mitigation (a)] = __________ | [Post-Project/Mitigation (b)] = __________

2.0 Velocity Reduction of Surface Water Flow

Index of Function = $[V_{micro} + V_{pcover} + V_{surfalt} + (V_{buffer} + V_{sed} + V_{source} + V_{upuse}) /4] /4$

Pre-Project/ Mitigation	= [_______ + _______ + _______ + (_______ + _______ + _______ + _______) /4] /4
Post-Project/ Mitigation	= [_______ + _______ + _______ + (_______ + _______ + _______ + _______) /4] /4

INDEX OF FUNCTION:

[Pre-Project/Mitigation (a)] = __________ | [Post-Project/Mitigation (b)] = __________

3.0 Elemental and Nutrient Cycling

Index of Function = $\{[(V_{som} + V_{detritus}) /2] \times [V_{pore} + (V_{source} + V_{surfalt} + V_{upuse}) /3] /3\}^{½}$

Pre-Project/ Mitigation	= {[(______ + ______) /2] x [______ + (______ + ______ + ______) /3] /3}^{½}
Post-Project/ Mitigation	= {[(______ + ______) /2] x [______ + (______ + ______ + ______) /3] /3}^{½}

INDEX OF FUNCTION:

[Pre-Project/Mitigation (a)] = __________ | [Post-Project/Mitigation (b)] = __________

4.0 Retention of Particulates and Organic Material

Index of Function = $[V_{sed} + (V_{buffer} + V_{pcover} + V_{upuse}) /3] /2$	
Pre-Project/ Mitigation	= [_______ + (_______ + _______ + _______) /3] /2
Post-Project/ Mitigation	= [_______ + (_______ + _______ + _______) /3] /2
INDEX OF FUNCTION:	
[Pre-Project/Mitigation (a)] = __________	[Post-Project/Mitigation (b)] = __________

5.0 Organic Carbon Export

Index of Function = $[V_{detritus} + V_{pcover} + V_{som} + (V_{micro} + V_{subalt} + V_{surfalt}) /3] /4$	
Pre-Project/ Mitigation	= [_______ + _______ + _______ + (_______ + _______ + _______) /3] /4
Post-Project/ Mitigation	= [_______ + _______ + _______ + (_______ + _______ + _______) /3] /4
INDEX OF FUNCTION:	
[Pre-Project/Mitigation (a)] = __________	[Post-Project/Mitigation (b)] = __________

6.0 Maintenance of Characteristic Plant Community

Index of Function = $[V_{pcover} + V_{pratio} + (V_{detritus} + V_{subalt} + V_{surfalt}) /3] /3$	
Pre-Project/ Mitigation	= [_______ + _______ + (_______ + _______ + _______) /3] /3
Post-Project/ Mitigation	= [_______ + _______ + (_______ + _______ + _______) /3] /3
INDEX OF FUNCTION:	
[Pre-Project/Mitigation (a)] = __________	[Post-Project/Mitigation (b)] = __________

7.0 Maintenance of Habitat Interspersion and Connectivity Among Wetlands	
Index of Function = $[V_{buffer} + V_{pcover} + V_{upuse} + (V_{subalt} + V_{surfalt}) /2] /4$	
Pre-Project/ Mitigation	= [_______ + _______ + _______ + (_______ + _______) /2] /4
Post-Project/ Mitigation	= [_______ + _______ + _______ + (_______ + _______) /2] /4
INDEX OF FUNCTION: [Pre-Project/Mitigation (a)] = __________	[Post-Project/Mitigation (b)] = __________

Form 3. Calculation of Functional Capacity Units (FCU's) and Post-Project Change in Functions (FCU's)

1.0 Moderation of Groundwater Flow	
Pre-Project FCI Score (a), from Form 2 ________ X Wetland Acres, from Form 1 ________ = Functional Capacity Units [FCU's (c)] = _______	*Post-Project* FCI Score (b), from Form 2 ________ X Wetland Acres, from Form 1 ________ = Functional Capacity Units [FCU's (d)] = ________
Calculation of Change in FCU's = [(d - c) / c] x 100 [(________ - ________) / ________] x 100 = ________ %	

2.0 Velocity Reduction of Surface Water Flow	
Pre-Project FCI Score (a), from Form 2 ________ X Wetland Acres, from Form 1 ________ = Functional Capacity Units [FCU's (c)] = _______	*Post-Project* FCI Score (b), from Form 2 ________ X Wetland Acres, from Form 1 ________ = Functional Capacity Units [FCU's (d)] = ________
Calculation of Change in FCU's = [(d - c) / c] x 100 [(________ - ________) / ________] x 100 = ________ %	

3.0 Retention, Conversion, and Release of Elements and Compounds	
Pre-Project FCI Score (a), from Form 2 ________ X Wetland Acres, from Form 1 ________ = Functional Capacity Units [FCU's (c)] = _______	*Post-Project* FCI Score (b), from Form 2 ________ X Wetland Acres, from Form 1 ________ = Functional Capacity Units [FCU's (d)] = ________
Calculation of Change in FCU's = [(d - c) / c] x 100 [(________ - ________) / ________] x 100 = ________ %	

4.0 Retention of Particulates and Organic Material	
Pre-Project FCI Score (a), from Form 2 ________ X Wetland Acres, from Form 1 ________ = Functional Capacity Units [FCU's (c)] = _______	*Post-Project* FCI Score (b), from Form 2 ________ X Wetland Acres, from Form 1 ________ = Functional Capacity Units [FCU's (d)] = ________
Calculation of Change in FCU's = [(d - c) / c] x 100 [(________ - ________) / ________] x 100 = ________ %	

5.0 Organic Carbon Export	
Pre-Project FCI Score (a), from Form 2 ________ X Wetland Acres, from Form 1 ________ = Functional Capacity Units [FCU's (c)] = _______	*Post-Project* FCI Score (b), from Form 2 ________ X Wetland Acres, from Form 1 ________ = Functional Capacity Units [FCU's (d)] = ________
Calculation of Change in FCU's = [(d - c) / c] x 100 [(________ - ________) / ________] x 100 = ________ %	

6.0 Maintenance of Characteristic Plant Community	
Pre-Project FCI Score (a), from Form 2 ________ X Wetland Acres, from Form 1 ________ = Functional Capacity Units [FCU's (c)] = _______	*Post-Project* FCI Score (b), from Form 2 ________ X Wetland Acres, from Form 1 ________ = Functional Capacity Units [FCU's (d)] = ________
Calculation of Change in FCU's = [(d - c) / c] x 100 [(________ - ________) / ________] x 100 = ________ %	

7.0 Maintenance of Habitat Interspersion and Connectivity Among Wetlands	
Pre-Project FCI Score (a), from Form 2 ________ X Wetland Acres, from Form 1 ________ = Functional Capacity Units [FCU's (c)] = _______	*Post-Project* FCI Score (b), from Form 2 ________ X Wetland Acres, from Form 1 ________ = Functional Capacity Units [FCU's (d)] = ________
Calculation of Change in FCU's = [(d - c) / c] x 100 [(________ - ________) / ________] x 100 = ________ %	

Table 4. Slope Wetland Functions and Associated Indicators (Variables)

Variable \ Function	1.0	2.0	3.0	4.0	5.0	6.0	7.0
V_{buffer}		X		X			X
$V_{detritus}$			X		X	X	
V_{micro}		X			X		
V_{pcover}	X	X		X	X	X	X
V_{pore}	X		X				
V_{pratio}						X	
V_{sed}		X		X			
V_{som}			X		X		
V_{source}	X	X	X				
V_{subalt}	X*				X	X	X
$V_{surfalt}$		X	X		X	X	X
V_{upuse}	X	X	X	X			X

* This variable controls the outcome of the function. If the variable is 0, the function will be 0.

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